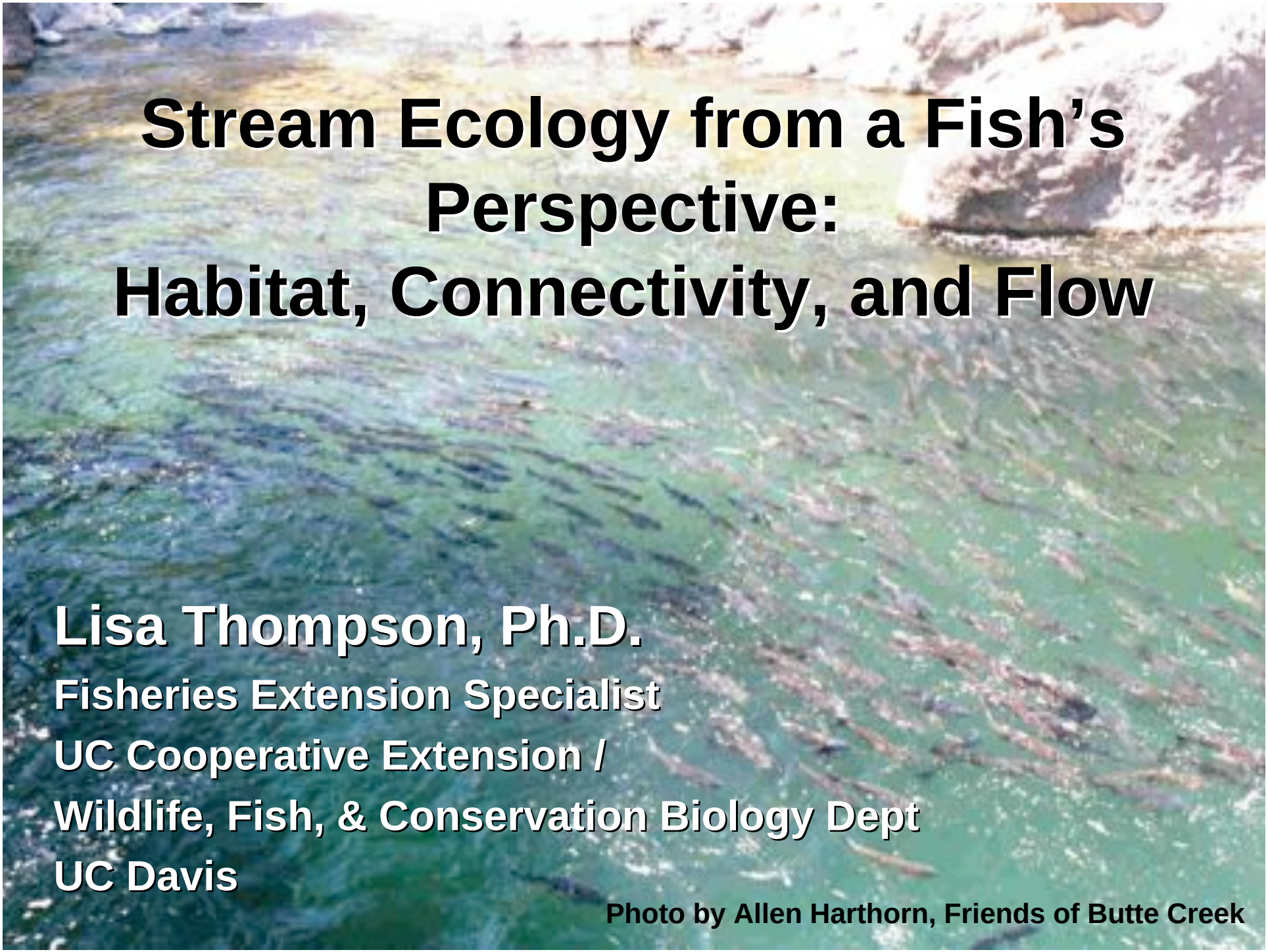

Stream Ecology from a Fish's Perspective: Habitat, Connectivity, and Flow

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Photo by Allen Harthorn, Friends of Butte Creek

Outline

- Watershed influence on habitat & fish
- Stream connectivity
- Flow regime
  - Pulsed releases

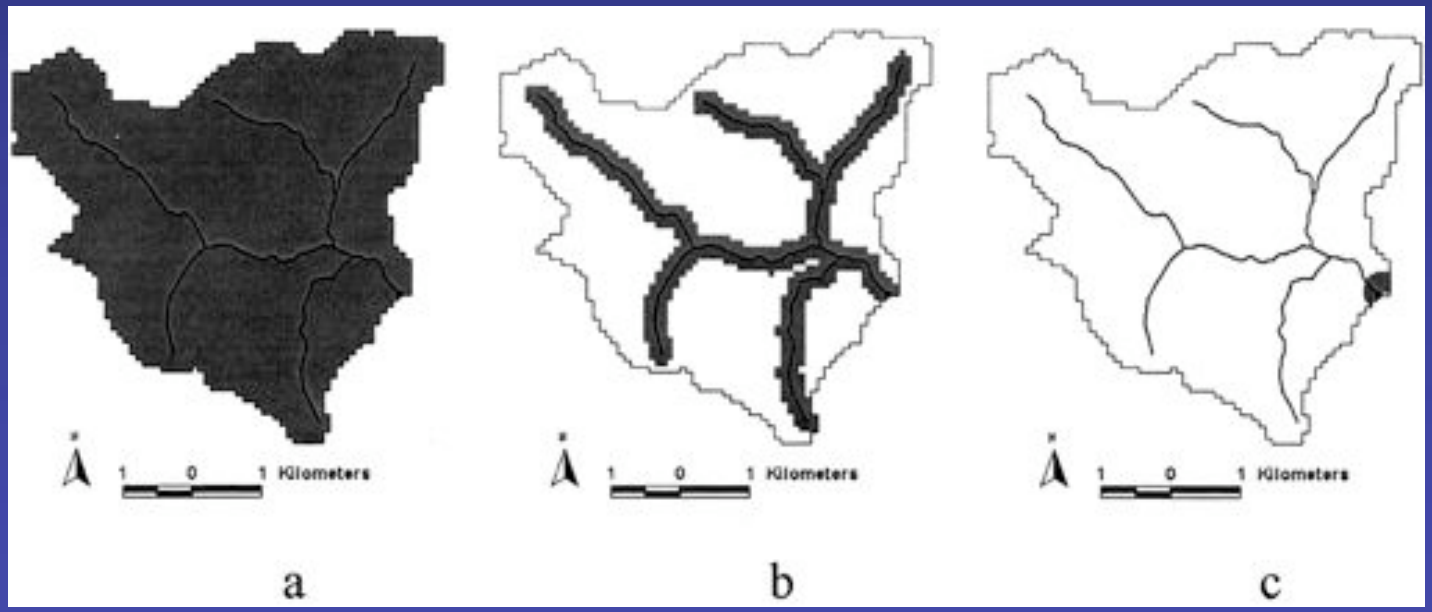
- Adaptive management experiments

Watershed Influence on Streams & Fish

- Fish distribution related to local habitat
- BUT…Streams are at the lowest point in the landscape
- Integrate impacts occurring higher up in the watershed (Naiman et al. 2002)
- Land use, water diversions, & tailwater return flows can affect:
  - Flashiness of flows
  - Temperature
  - Dissolved oxygen
  - Sediment load
  - Contaminants

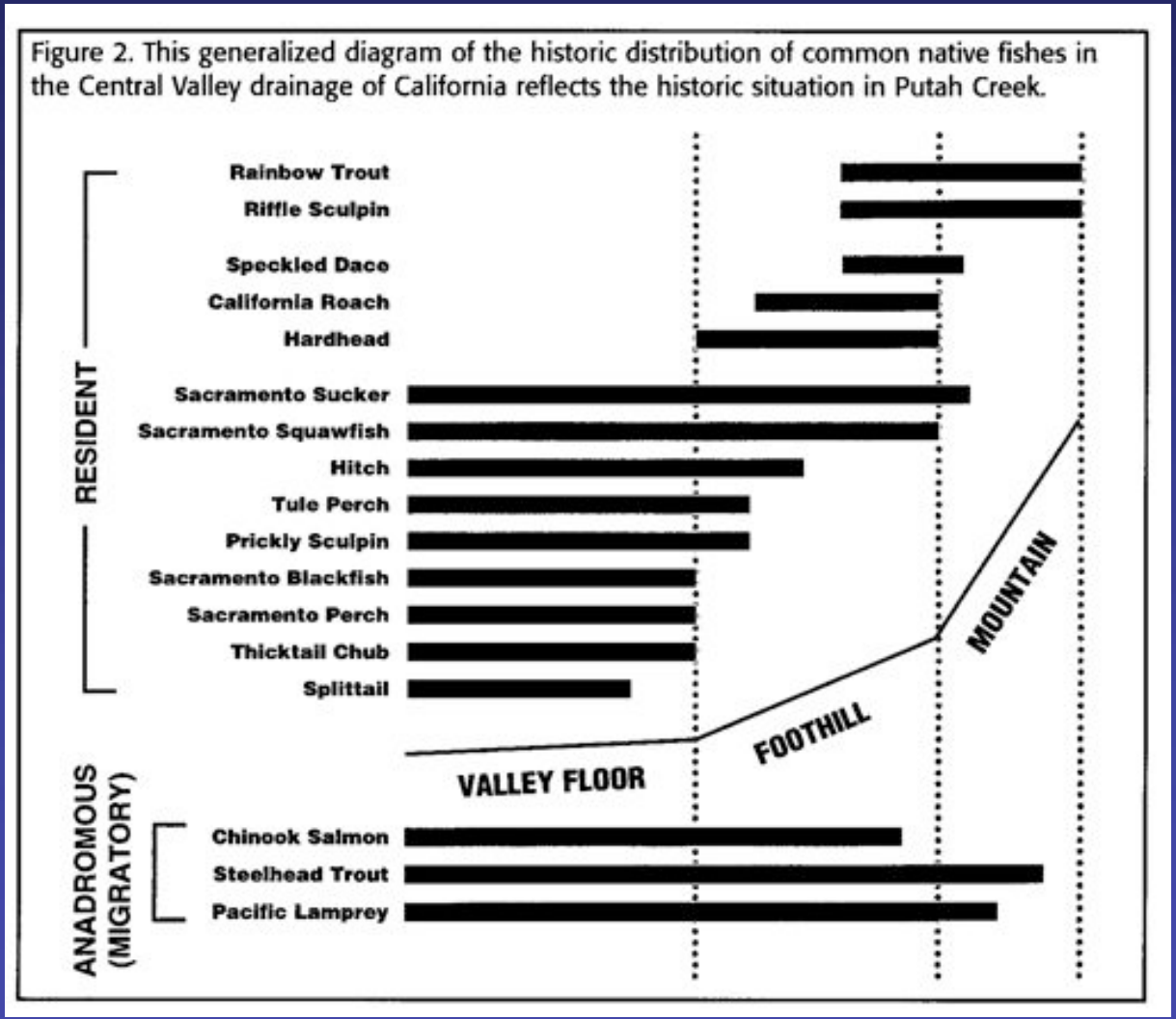
Land Cover & Scale

- Fish species richness related to land cover in
  - Entire watershed
  - Riparian corridor
- Macroinvertebrate species richness related to land cover in riparian corridor



(Strayer et al. 2003)

Historic Distribution of Native Fishes in the Central Valley



Cold-water species at higher elevations

(Moyle et al. 1998)

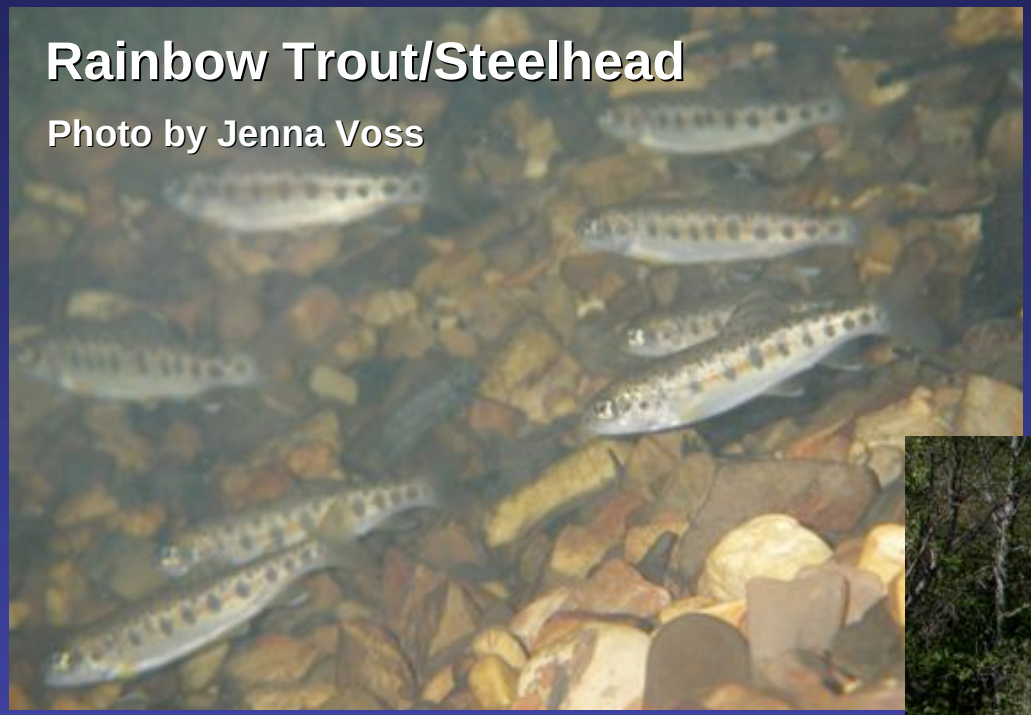
Habitat Loss & Destruction in California

- **Forestry, mining, agriculture, urban development**
  - **High water temperature**
  - **Low dissolved oxygen**
  - **Excess fine sediment**
  - **Less overhead cover**
  - **Less large wood**

Cow Creek Fish Distribution Study

- East of Redding, CA
- Land use = rangeland
- Irrigation diversions
- Habitat for *threatened* Central Valley steelhead trout
- Potential habitat for *threatened* spring-run Chinook salmon

Within-Season Fish Distribution

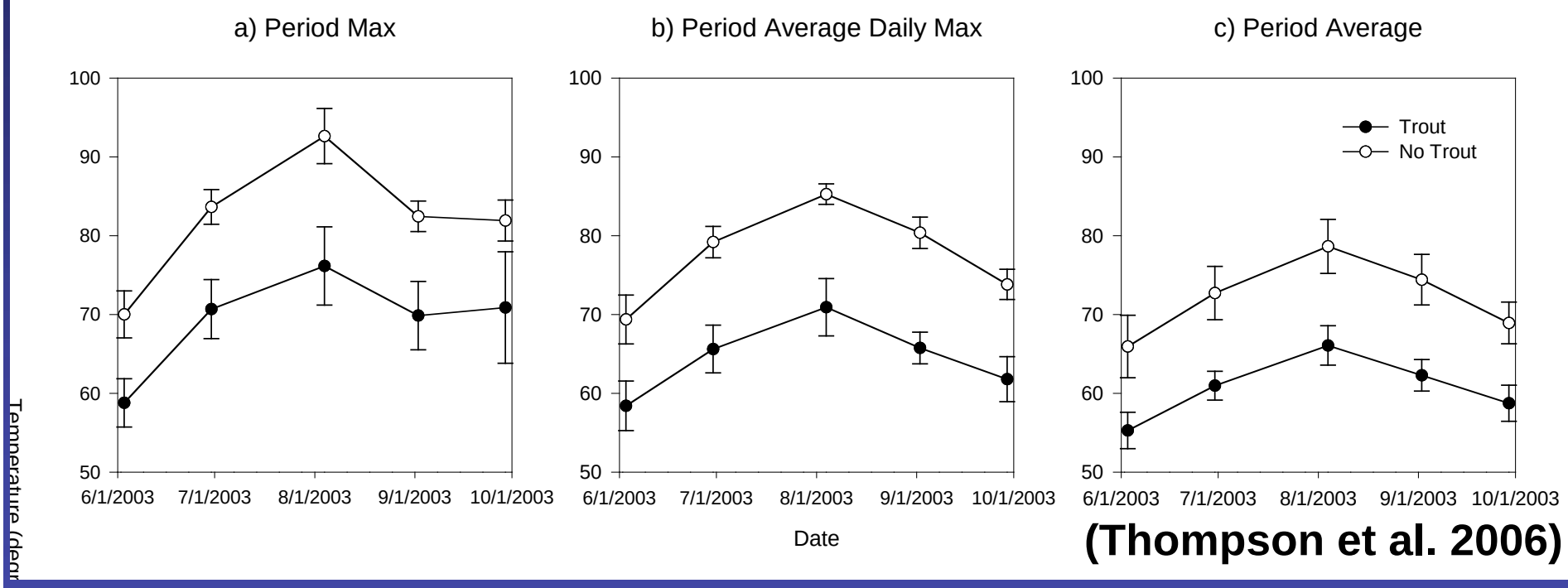


Trout presence/absence

Pool habitat – Trout more likely to be present in deeper pools

Temperature Across Season

Period Max **Period Avg Daily Max** **Period Avg**



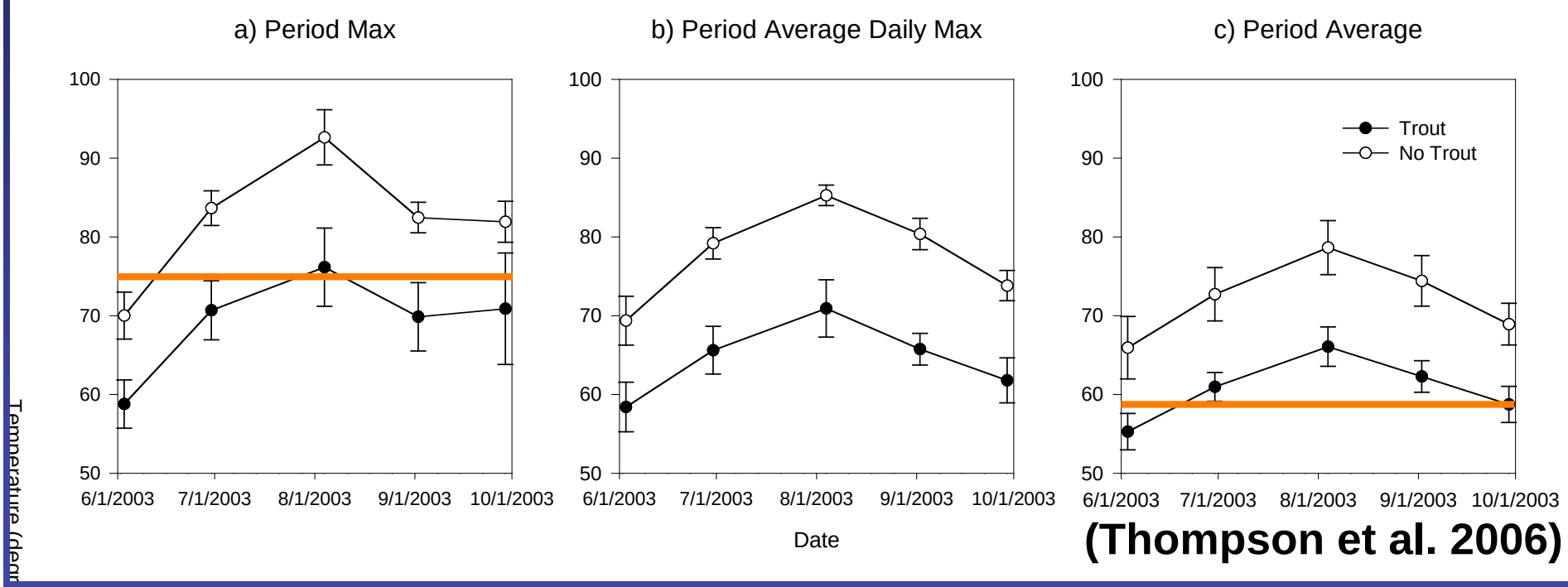
(Thompson et al. 2006)

Black = Pools with trout in mid-summer

White = Pools without trout in mid-summer

Temperature Across Season

Period Max **Period Avg Daily Max** **Period Avg**



(Thompson et al. 2006)

Black = Pools with trout in mid-summer

White = Pools without trout in mid-summer

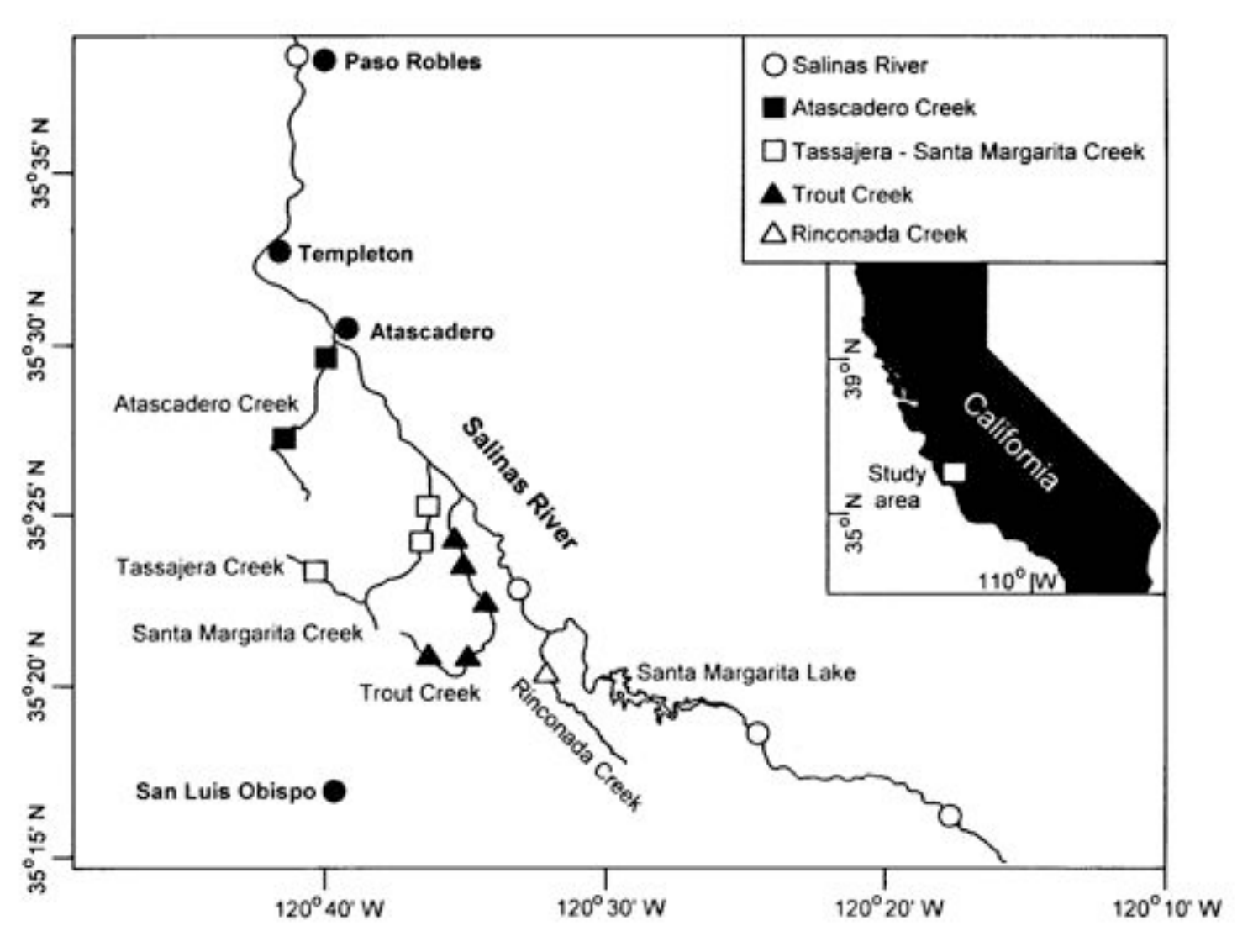
Temperature – a Key Variable

- Tension point about 1,000’ elevation
- Water temperature criteria vary for different life stages
  - Egg incubation
  - Juvenile rearing
  - Migration
  - Spawning
- High water temperatures increase fishes’ metabolic rate & food requirements

- Other variables?

South-Central California Coast Steelhead
Threatened/Endangered

Upper Salinas River Watershed



Thompson et al. (In review)

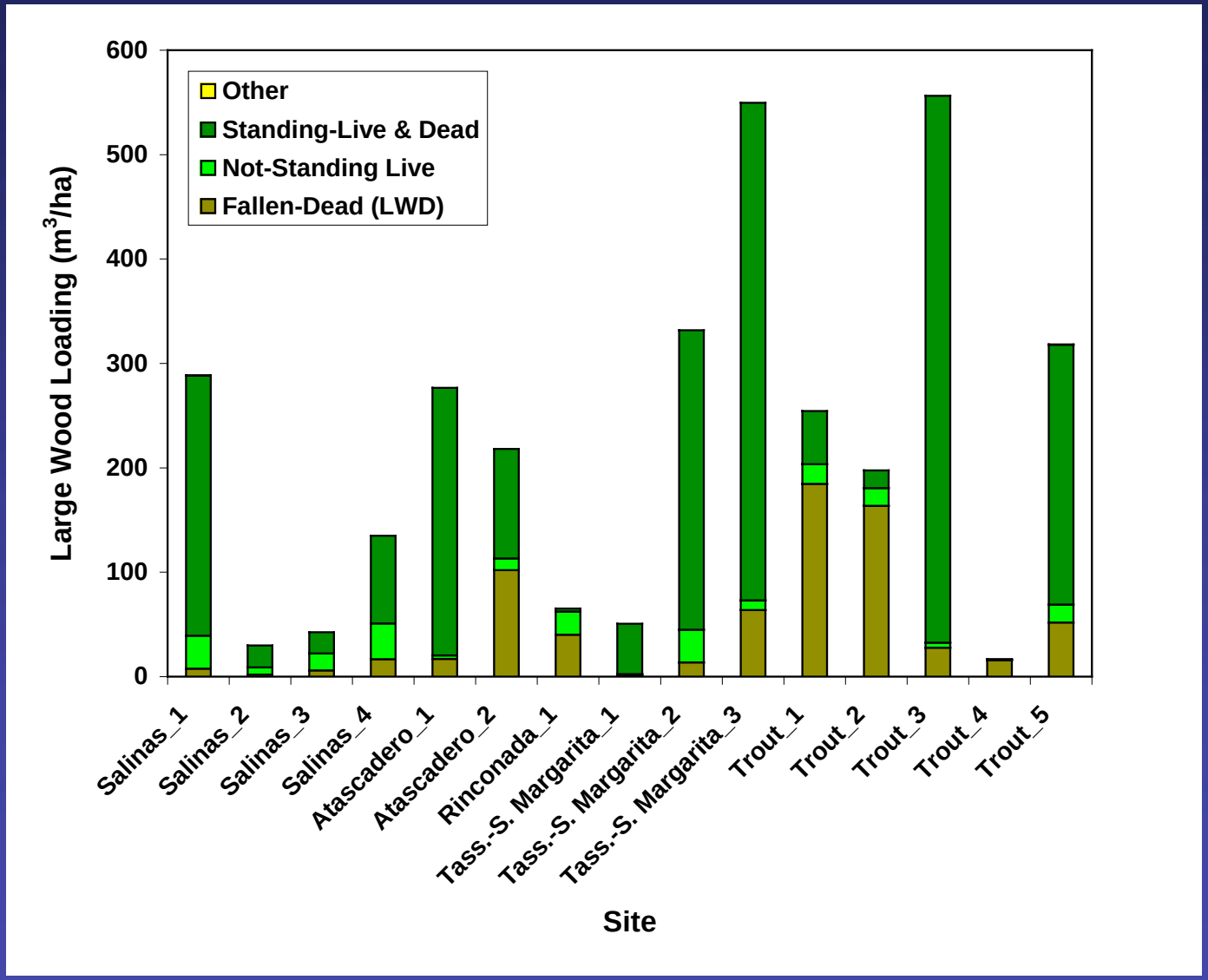
Large Wood Sampling

- **Large wood volume within bankfull width**
  - **≥ 3 feet long, ≥ 4 inches diameter**
  - **Fallen, dead**
  - **Non-standing, live**
  - **Standing live & dead**
- **Recruitment**
  - **Standing trees within riparian**
  - **Regeneration of oak & sycamore a concern**

Bankfull Width

- Stream rises to this level about once every 1.5 years

Large Wood Loading



Thompson et al. (In review)

Salinas Large Wood vs. Other Regions
(Fallen dead wood only)

Region	n	Mean (m^3/ha)	Median (m^3/ha)	Maximum (m^3/ha)
Pacific Northwest (BC, WA, OR) [a]	62	752	535	4,500
Sierra Nevada conifer [b]	12	160	159	382
No. CA hardwood, protected watersheds [c]	9	115	107	173
No. CA hardwood, private land [c]	23	42	20	146
So. CA hardwood (this study)	15	47	17	164

a Data from Andrus et al. (1988), Harmon et al. (1986), and Keller and Tally (1979).
b Data from Berg et al. (1998)
c Data from Opperman (2005)

Thompson et al. (In review)

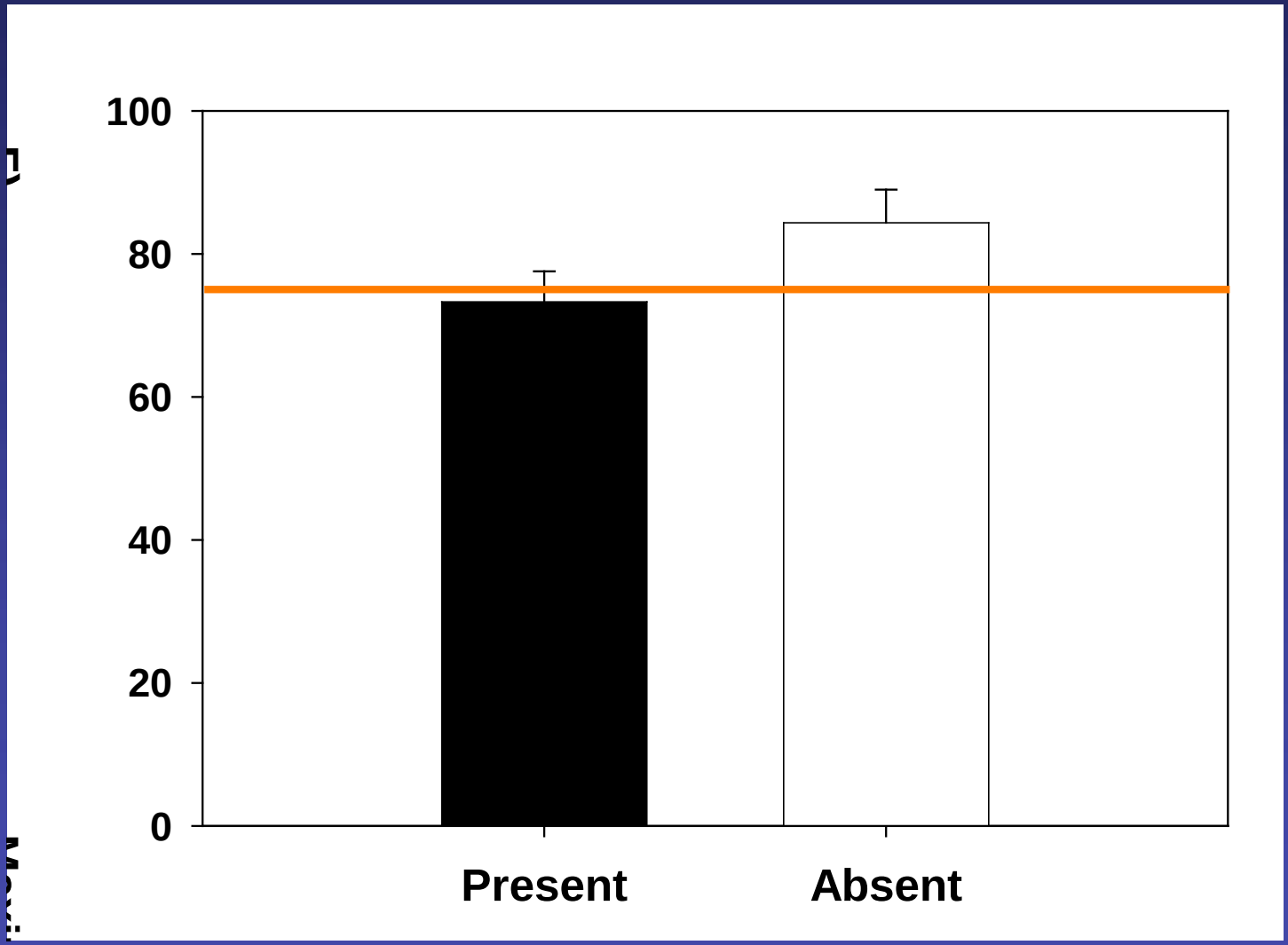
Pool Formation

At 13 sites at least 1/2 the pools were formed due to large wood, or influenced by large wood.

Wood jam

Wood influence

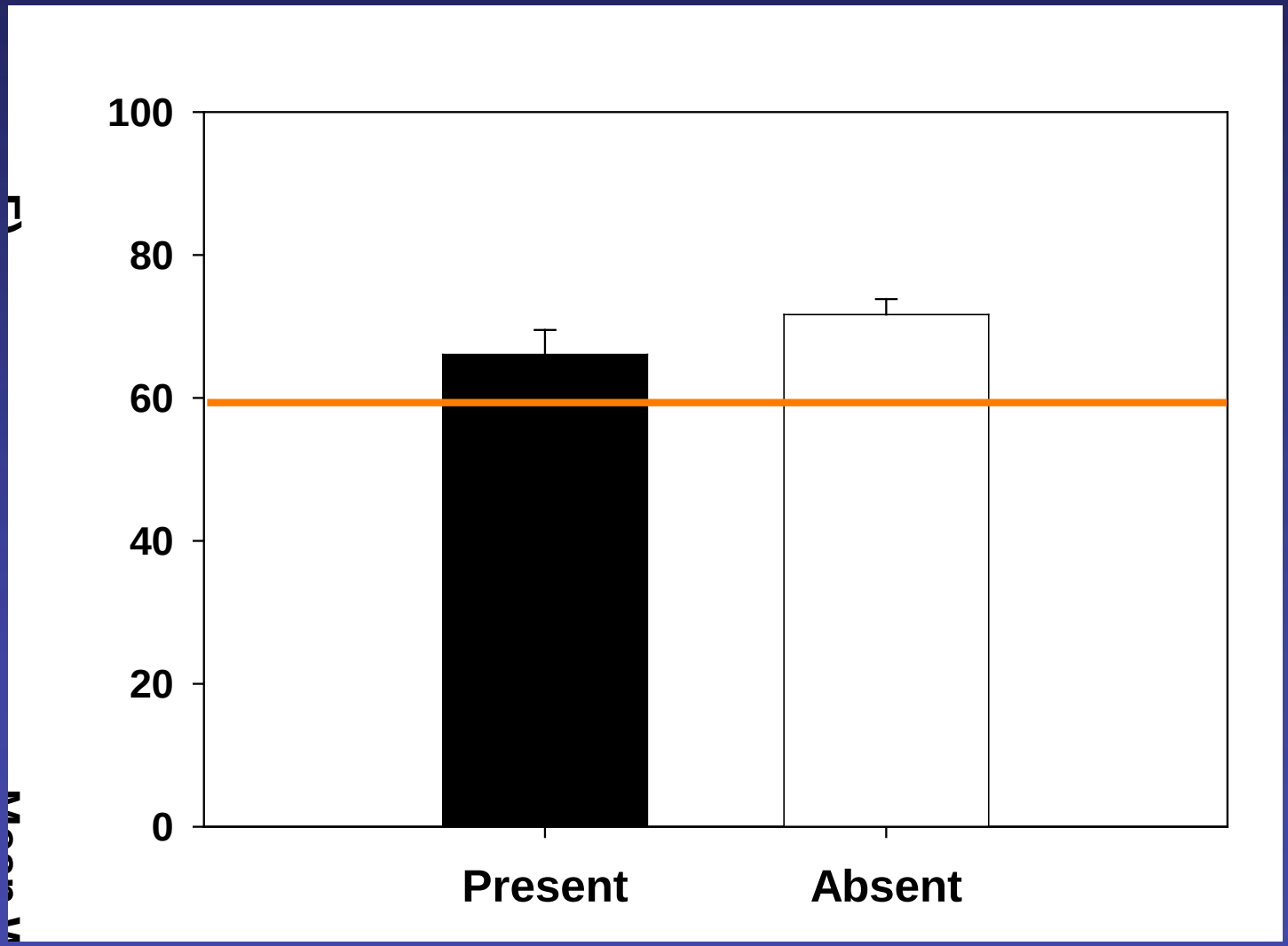
Steelhead Presence vs. Max Temperature



p = 0.02

Thompson et al. (In prep)

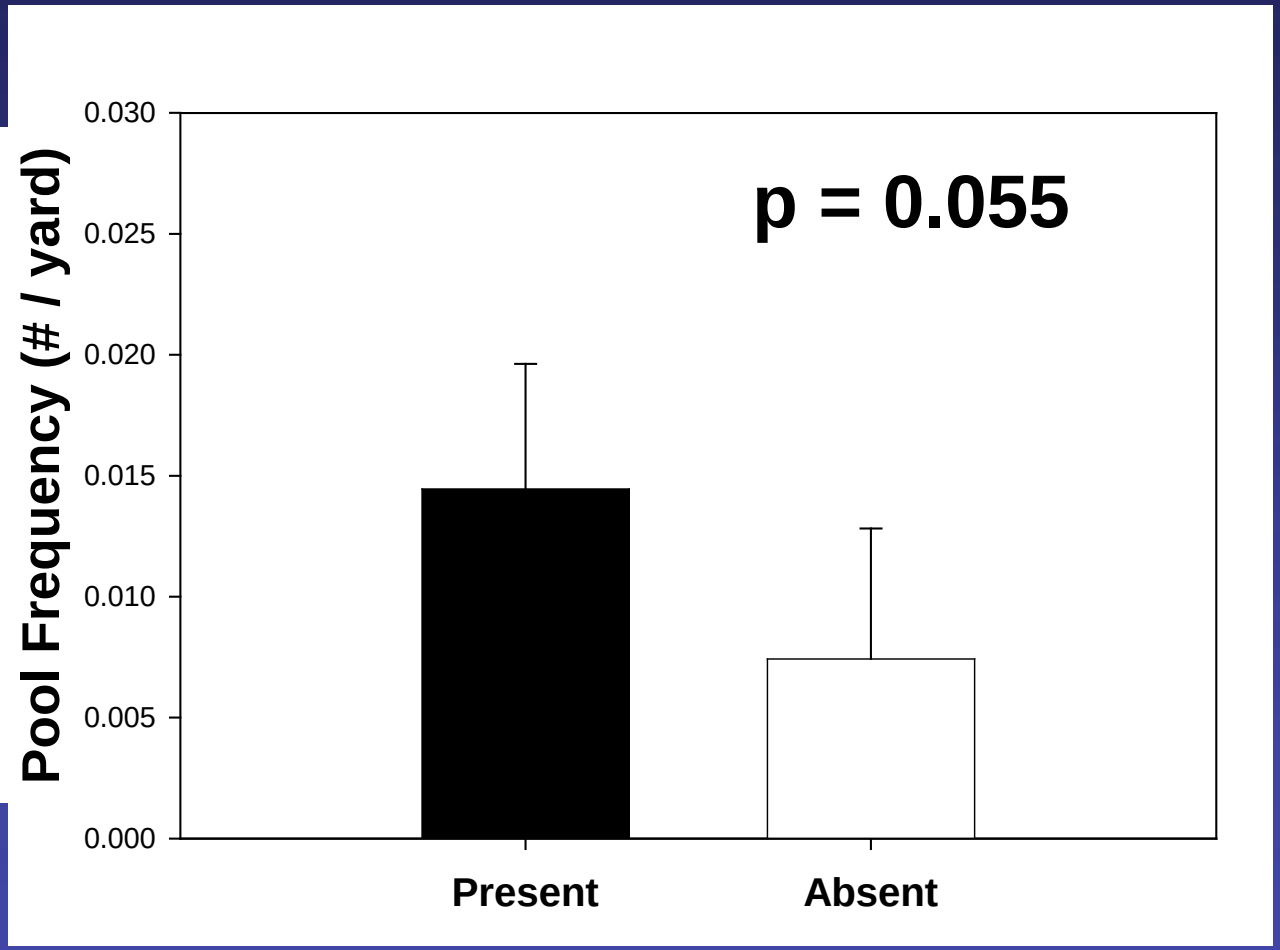
Steelhead Presence vs. Avg. Temperature

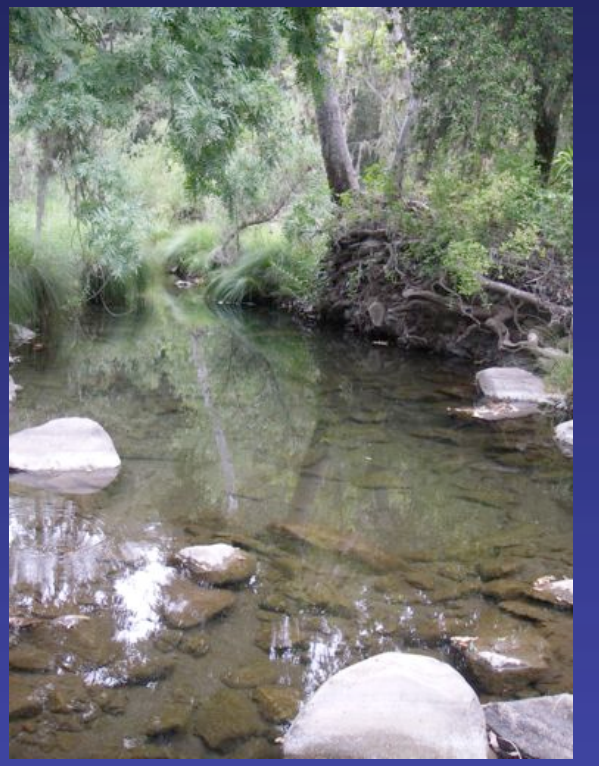


p = 0.07

Thompson et al. (In prep)

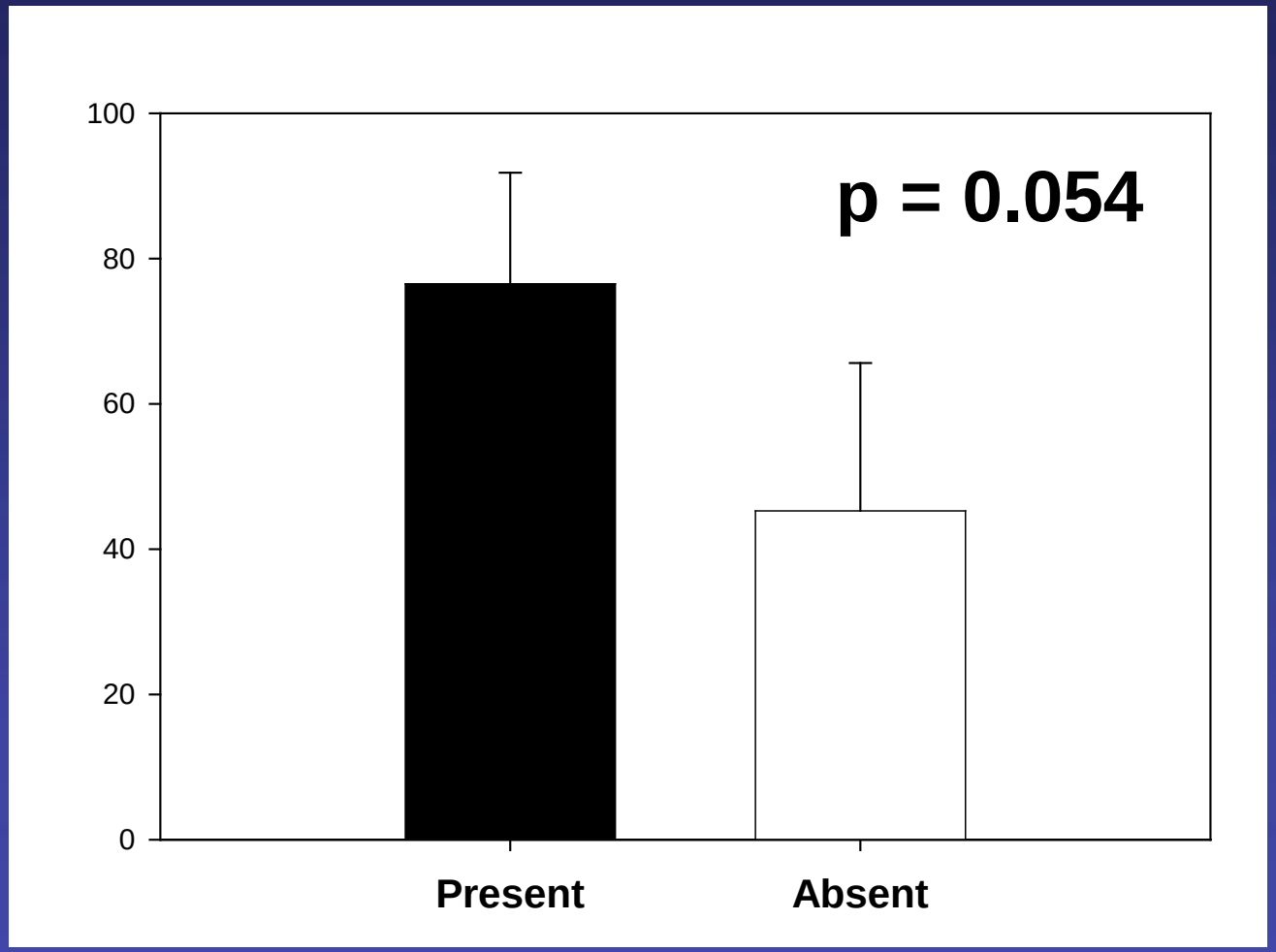
Steelhead Presence vs. Pools

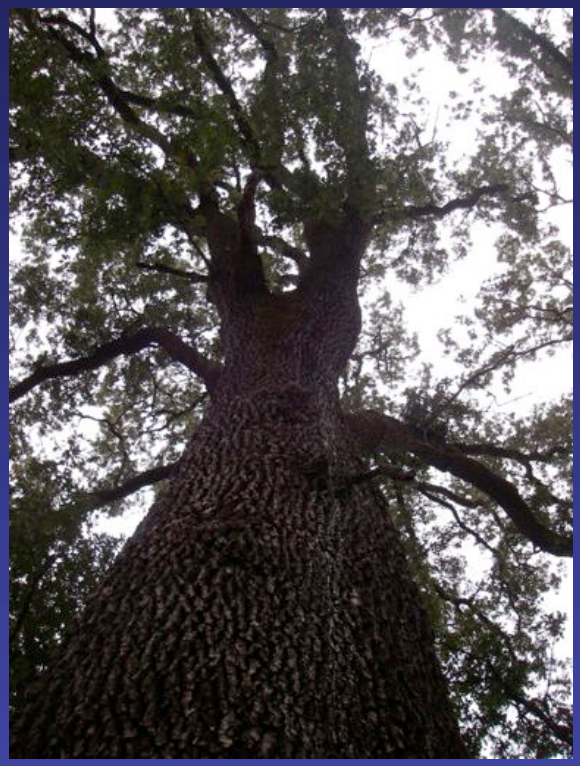




Thompson et al. (In prep)

Steelhead Presence vs. Cover



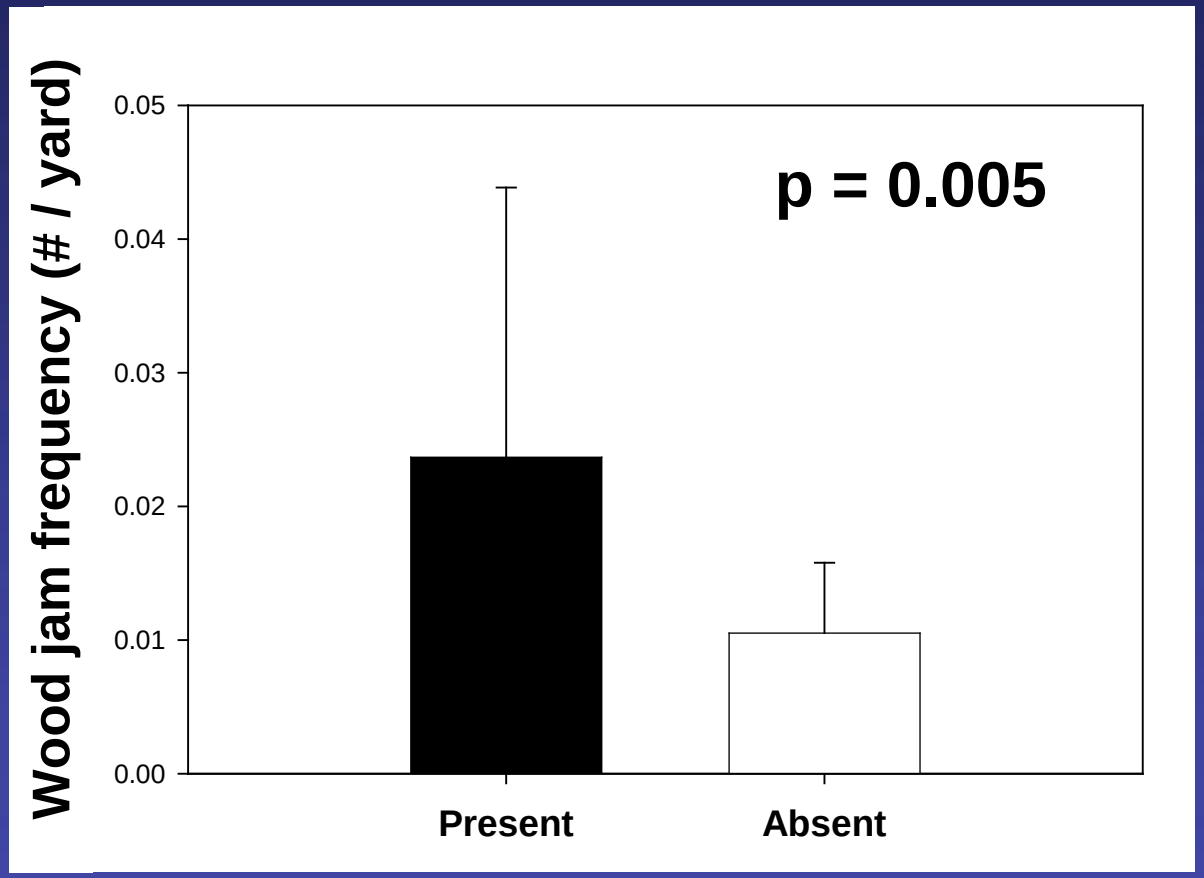


Thompson et al. (In prep)

What about the wood?

- **Young-of-the-year steelhead were in riffles, not pools**

Adult Steelhead Presence vs. Wood Jams

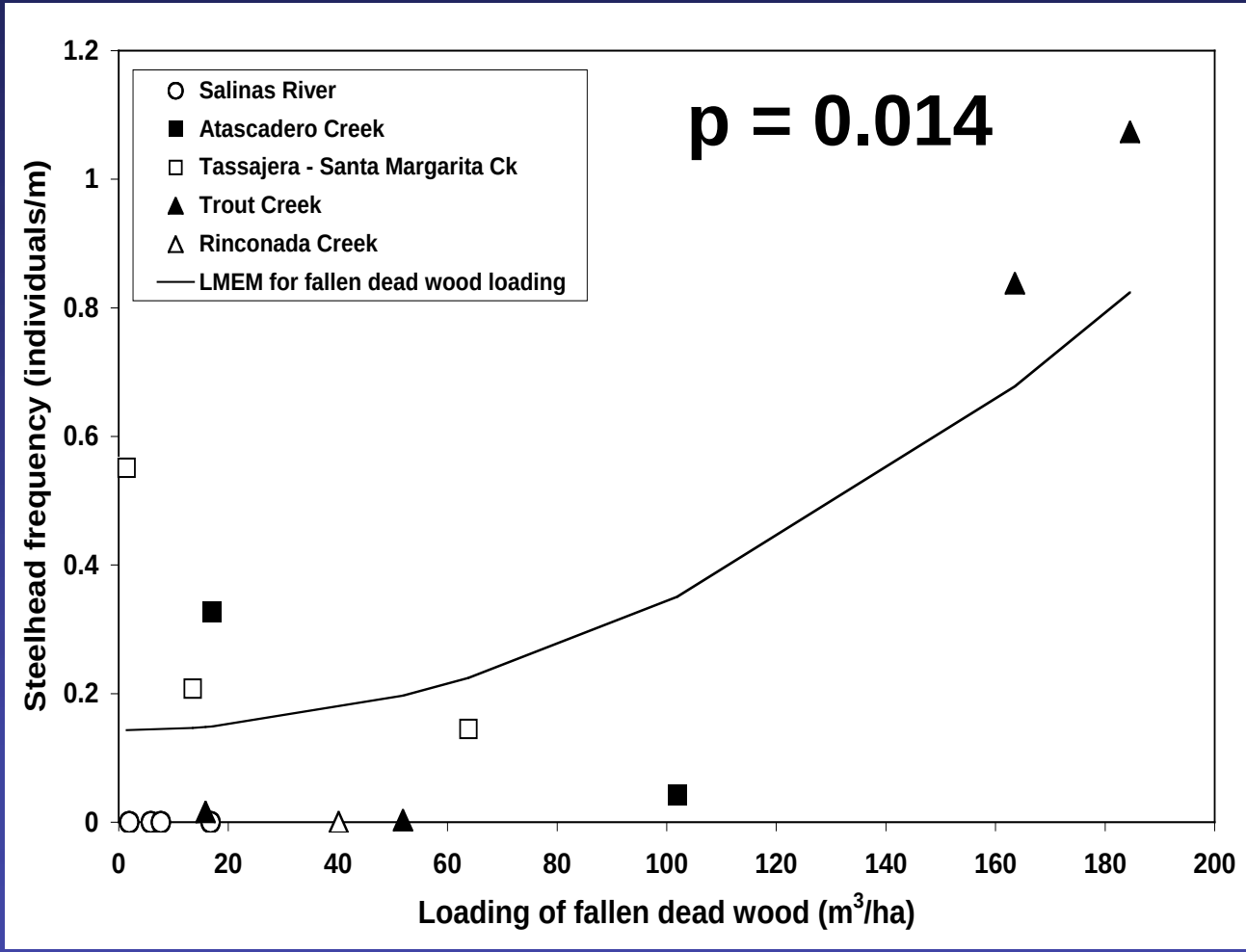


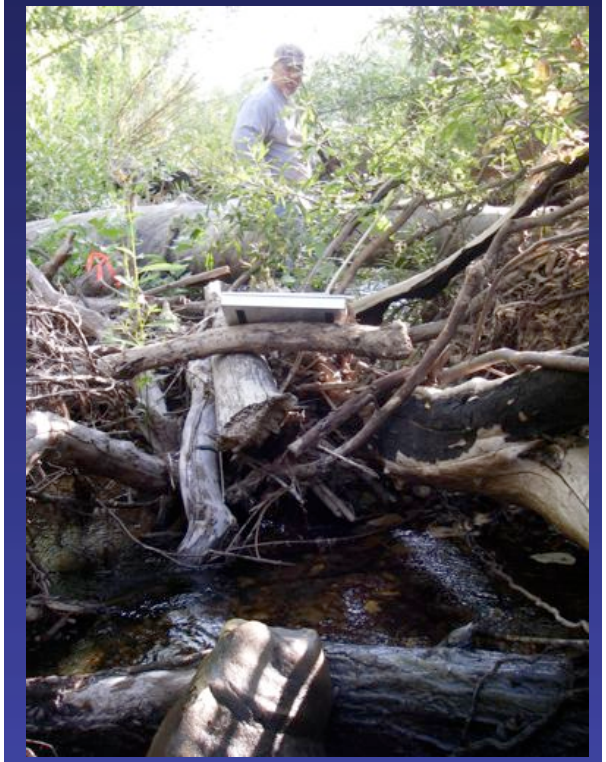
Thompson et al. (In prep)

Steelhead Frequency

- **Steelhead more frequent at sites with**
  - **Higher fallen dead large wood loading**
  - **Cooler average water temperature**
  - **Cooler maximum water temperature**

Steelhead Frequency vs. Dead Wood





Thompson et al. (In prep)

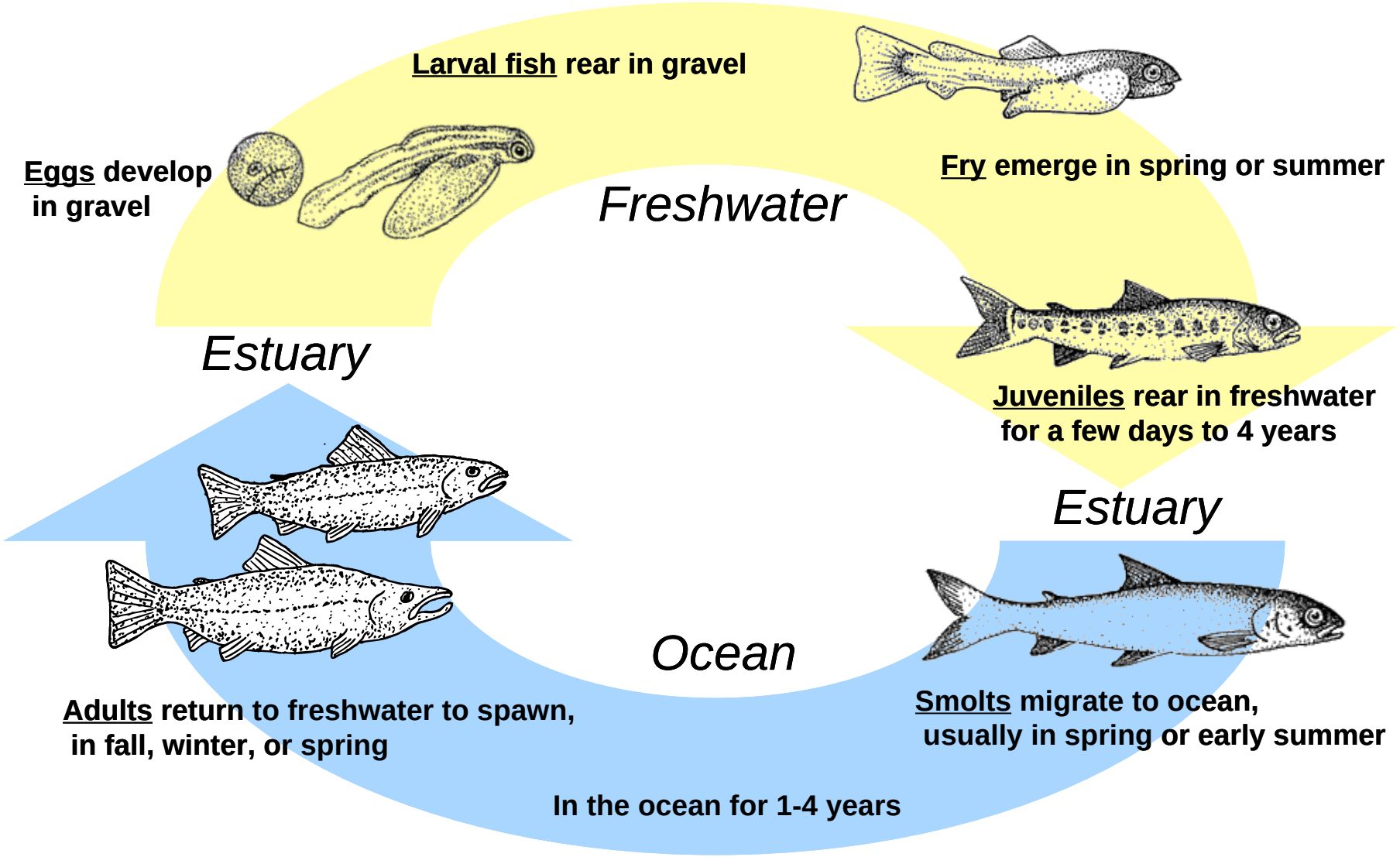
Stream Connectivity

- **Longitudinal & lateral connectivity essential to viability of many species (Bunn & Arthington 2002)**
- **Important for both anadromous and resident fish**

Anadromous Salmonids

- **Salmon & steelhead use entire watershed**
  - **Network of streams and rivers is a roadway**

Anadromous Fish Life Cycle



Dams & Barriers are Roadblocks to Fish

Shasta Dam, 1945, Central Valley Project.
Dams & water diversions block fish movement to headwaters of Valley streams

Diversions = Detours

Federal project

State project

Local project

Wild & scenic

Natural lake, river

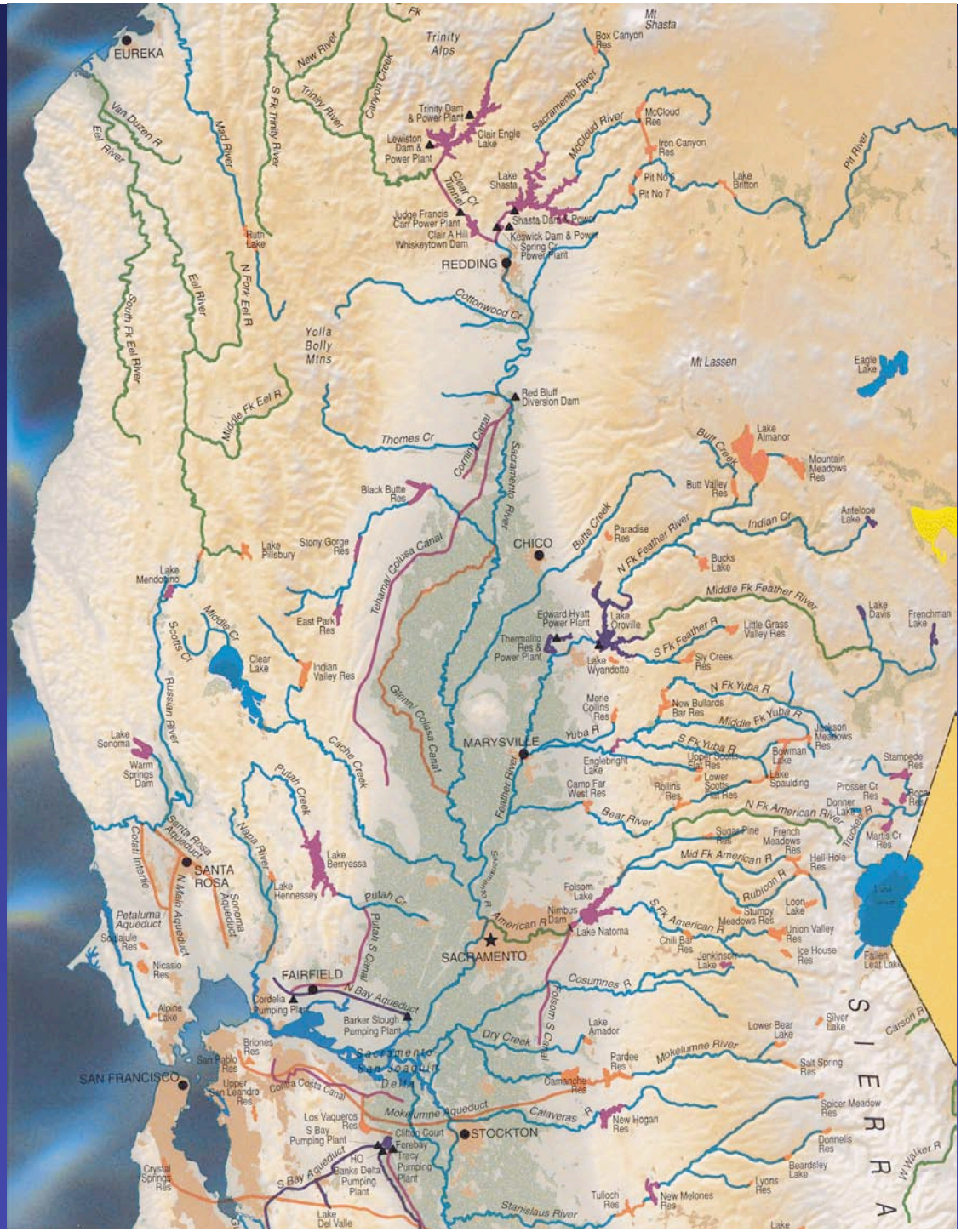
Saline / alkaline lake

Irrigated area

Urbanized area

Pumping or power plant

Map courtesy of the Water Education Foundation



Cow Creek - Chinook Salmon Spawners

- **Must pass Red Bluff Diversion Dam on Sacramento River to reach creek**

Small Scale Barriers

- Culverts & irrigation dams may impede upstream movement of resident fish to cooler water

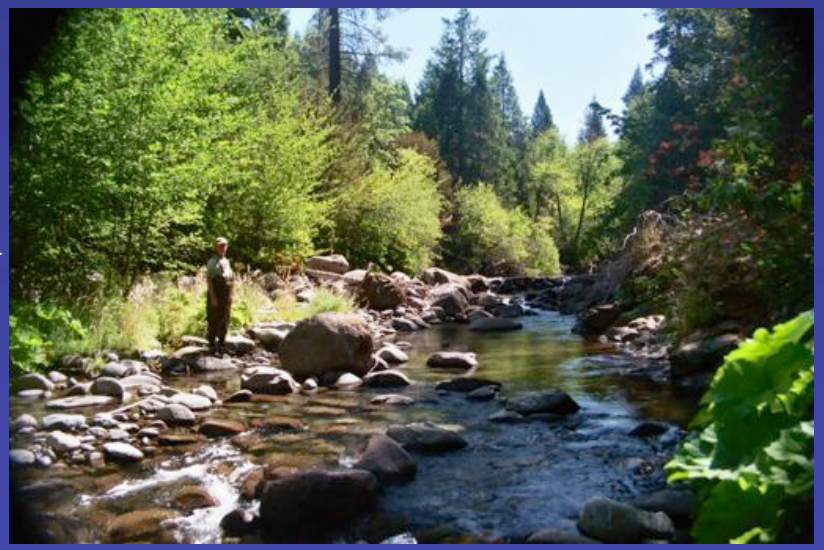
Culverts

Flashboard dam

Resident Fish in Cow Creek

- Spring
  - Rainbow trout at both high & low elevations
- Mid-summer
  - Rainbow trout found only in cooler, higher elevation pools (Thompson et al. 2006)
- Are they moving upstream?

?

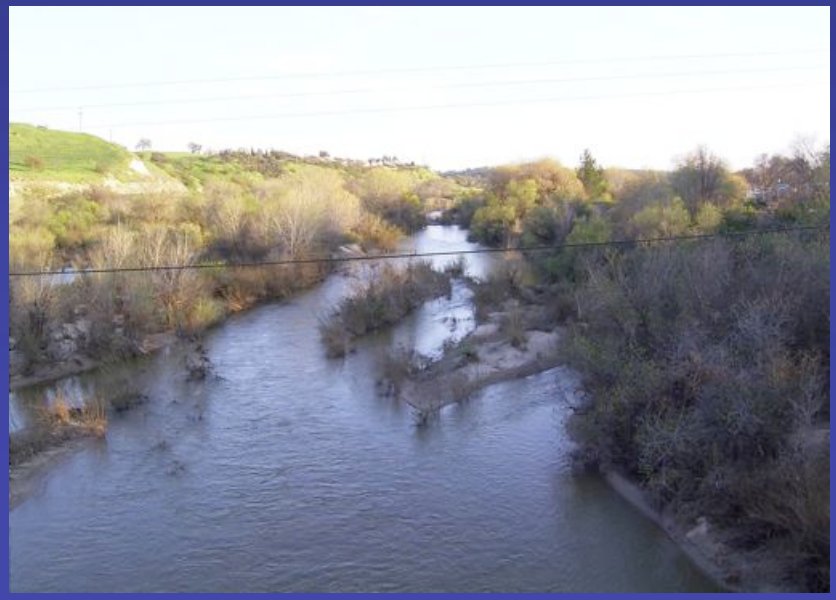


Resident Fish in the Salinas River Watershed

Between-Year Movement

- 2004
  - Dry year
  - Steelhead only at high elevations

- 2005
  - Good water year
  - Steelhead at both high & low elevations in tributaries



Flow Regime

- **Natural flow regime (Poff et al. 1997)**
  - **Every stream has a characteristic natural water flow pattern & an associated animal and plant community (Naiman et al. 2002)**
- **Flow alteration in California**
  - **Water from winter snow & rain held in reservoirs, then released later in the year**
  - **Reverses natural flow timing**

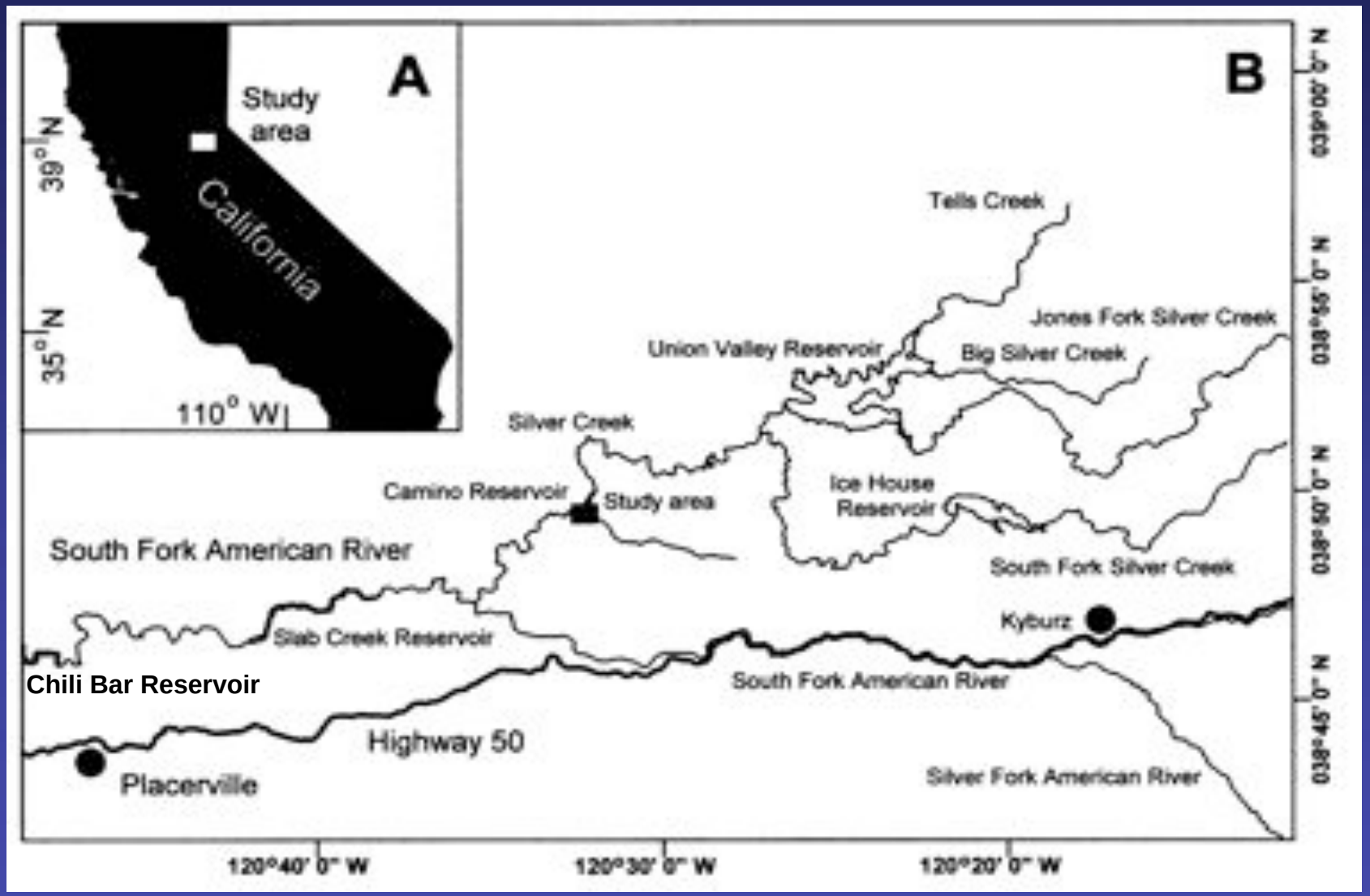
Pulsed Flows

- Flow is artificially released
- Timing & frequency deviates from normal hydrograph
- Do pulsed flows adversely affect the behavior of fishes?

Before a pulsed release

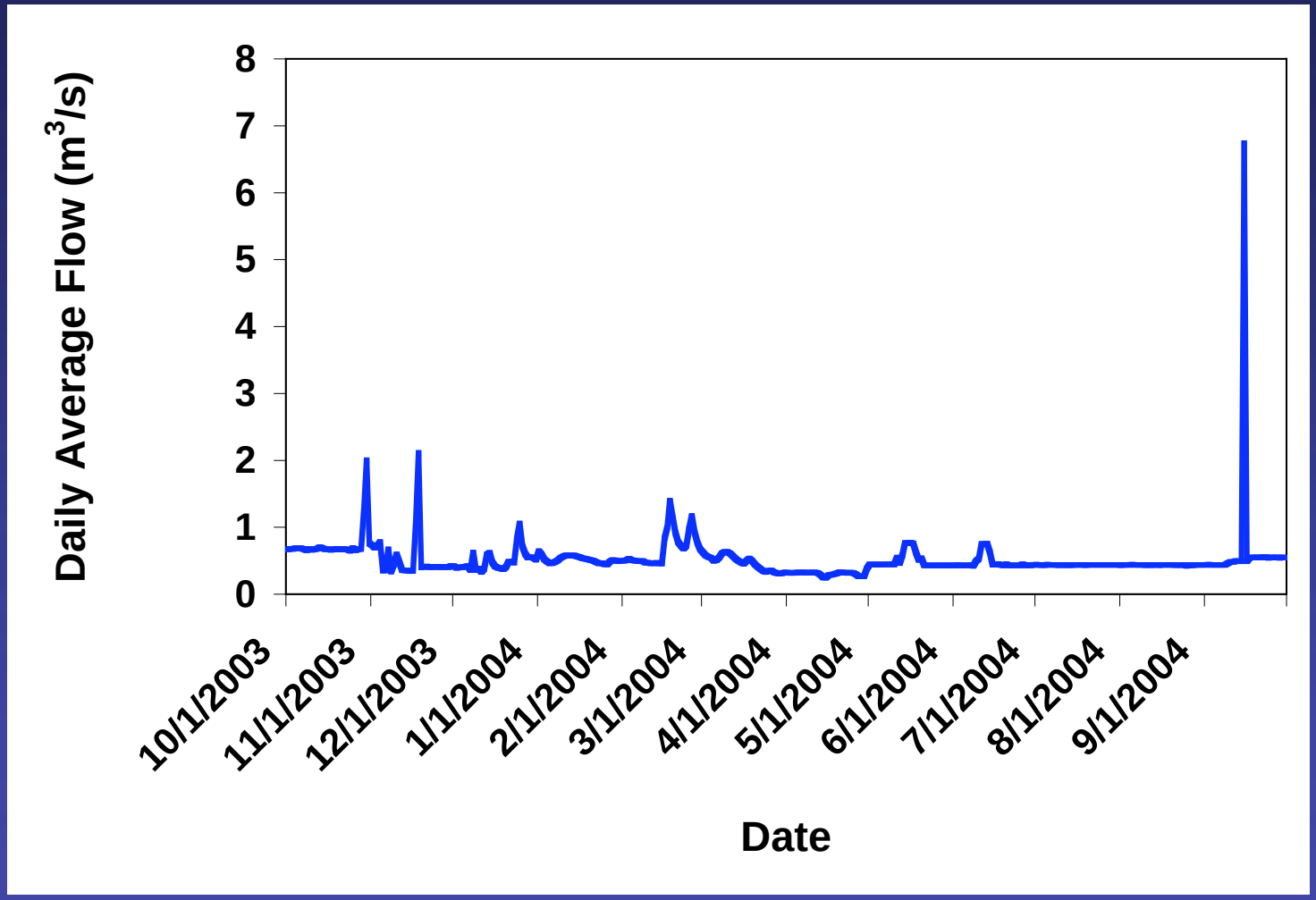
During a pulsed release

South Fork American River Watershed



Thompson et al. (In prep)

Silver Creek Daily Average Flow, 2003-04

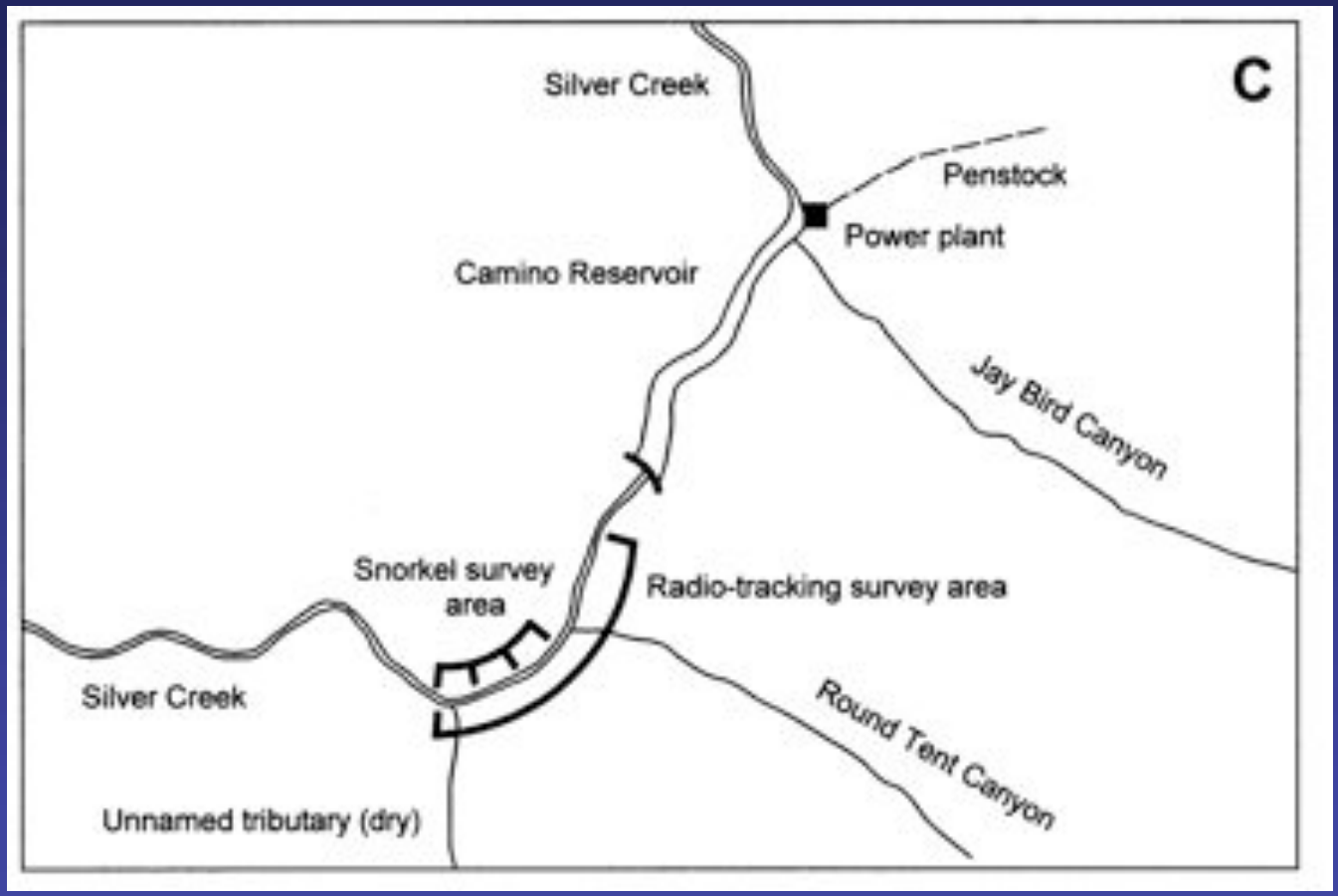


Flow data courtesy of Sacramento Municipal Utility District

Thompson et al. (In prep)

Silver Creek Before & During Pulse

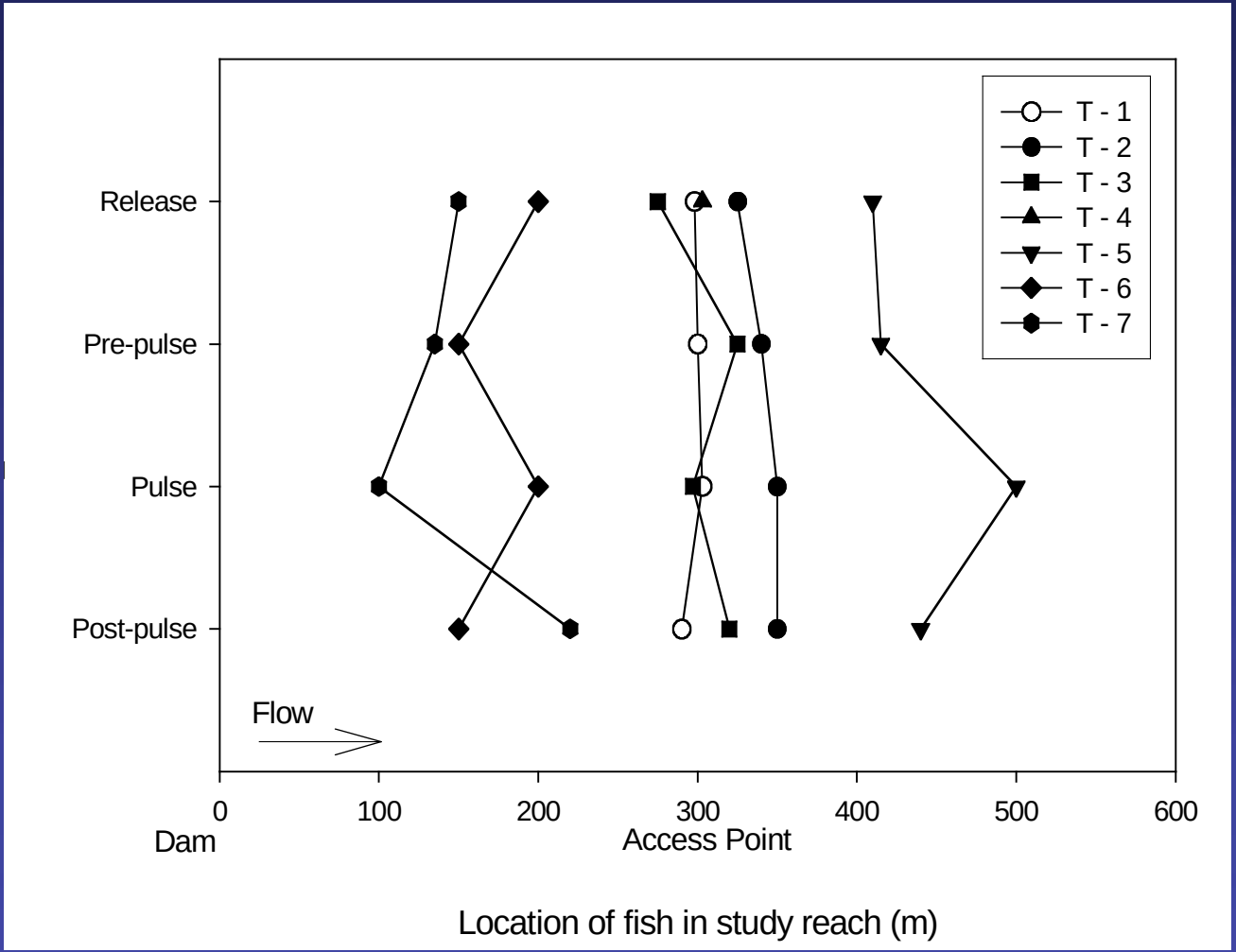
Silver Creek Map



- 15 m drop in elevation along reach
- 500 m radio-tracking section
- Three 100 m snorkel sections

Thompson et al. (In prep)

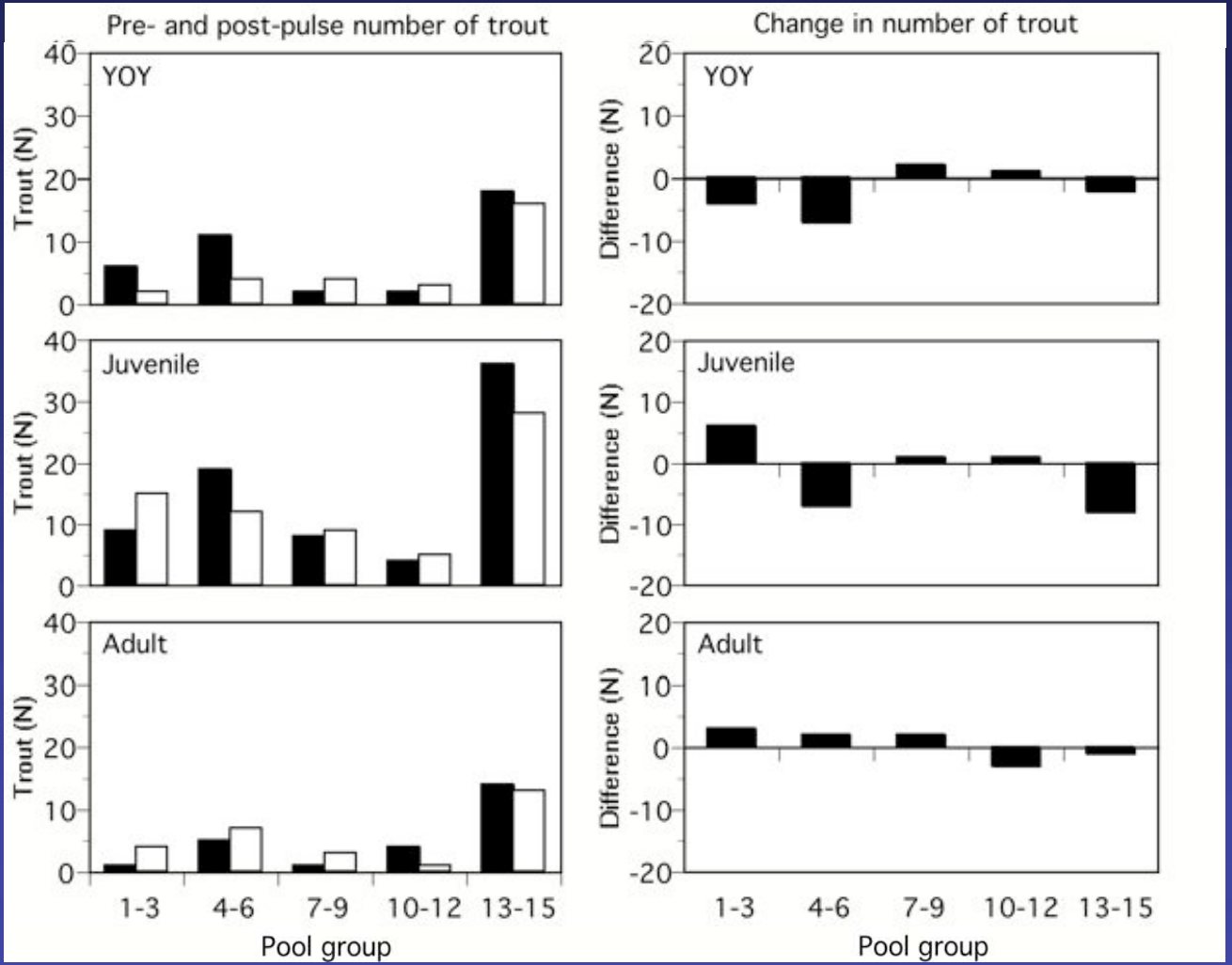
Movement of Radio-Tagged Trout



- Trout tended to stay in the same location in the creek

Thompson et al. (In prep)

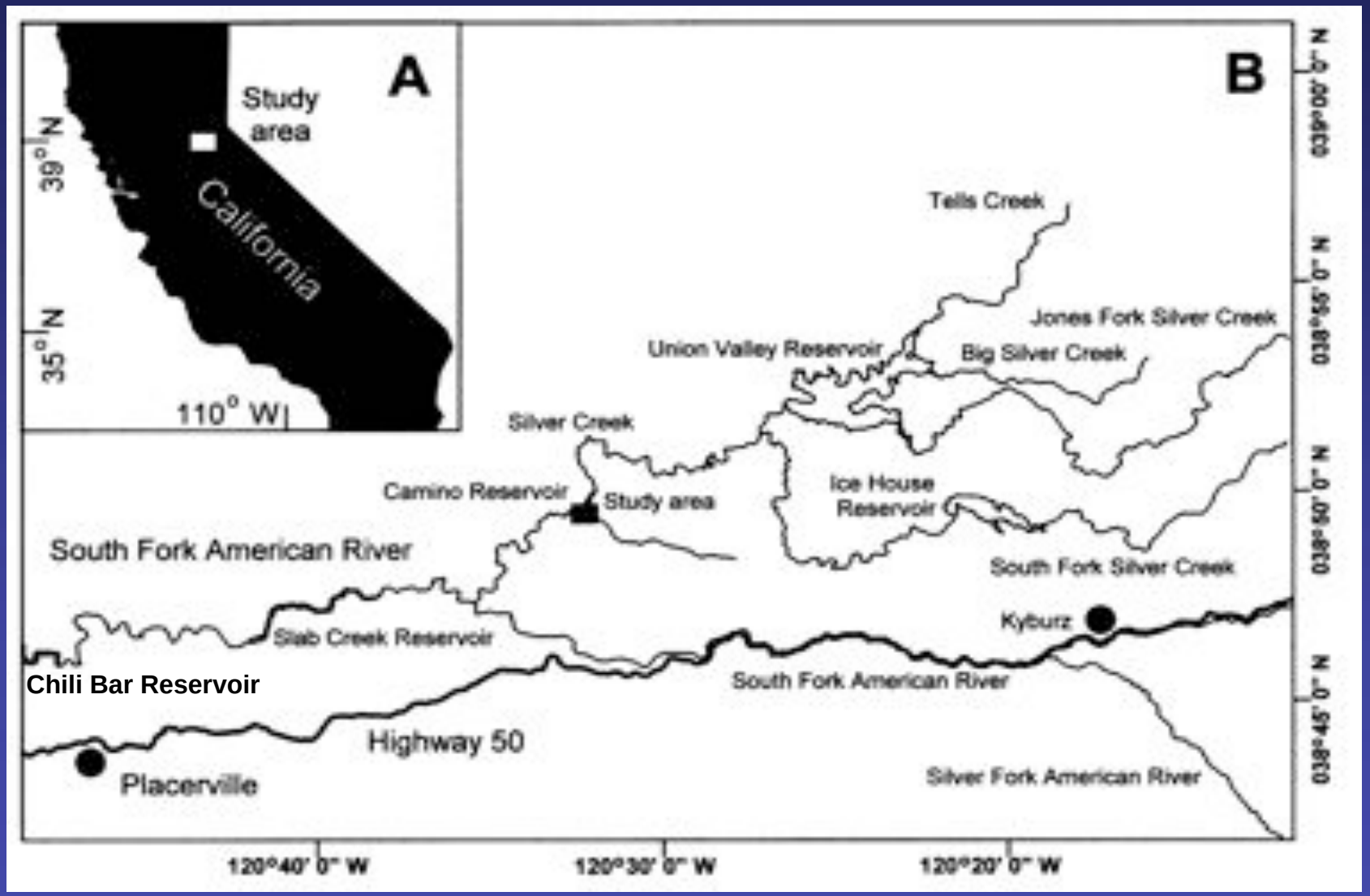
Snorkel Counts



- No clear evidence of downstream displacement

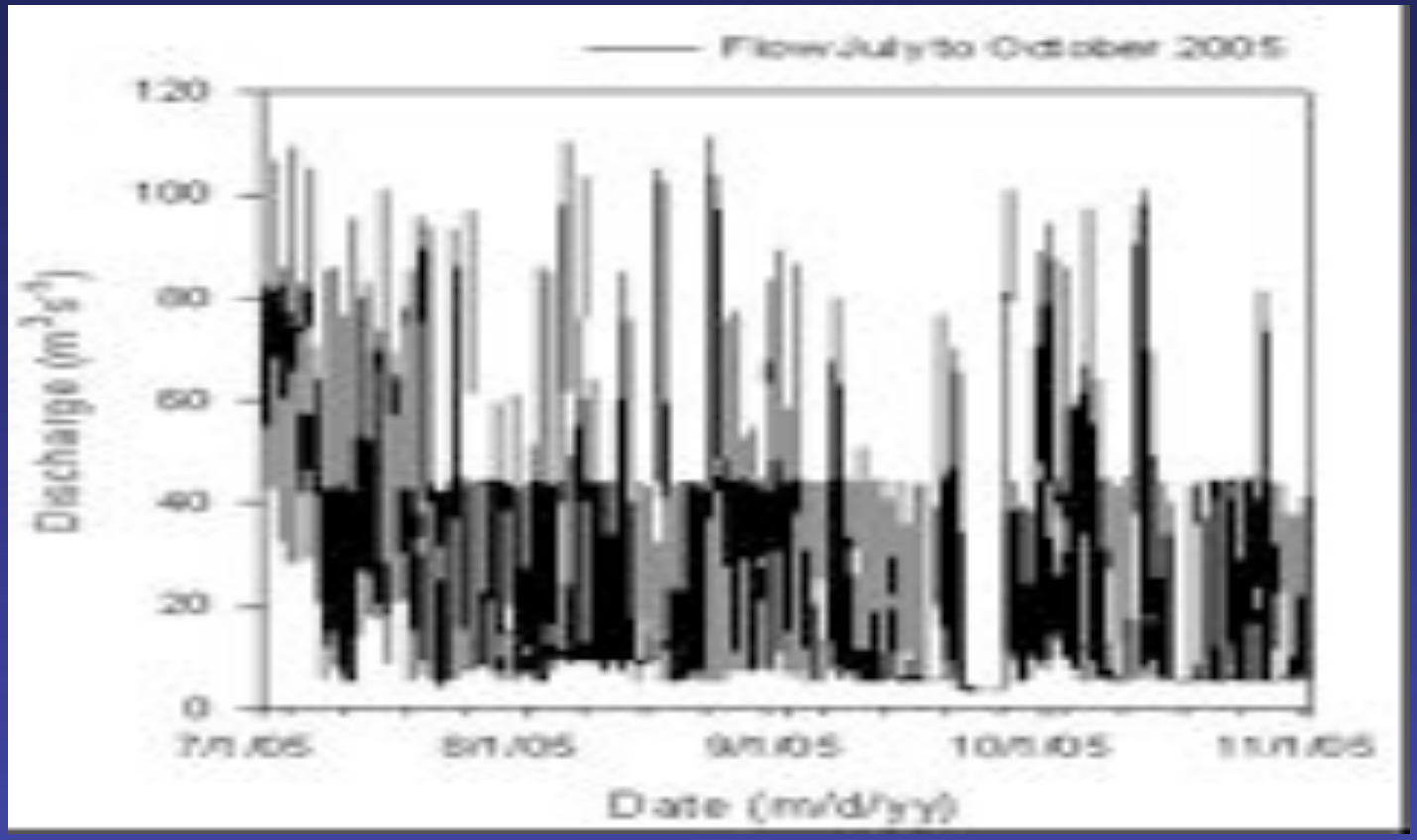
Thompson et al. (In prep)

South Fork American River Watershed



Thompson et al. (In prep)

Pulsed Releases in the South Fork



- One or more pulsed releases per day
- Flow increases from 5 m^3/s to 40 m^3/s
- Artificial releases from mid July to November
- 1 m^3/s ~ 35 cfs

Hamilton et al. (In prep)

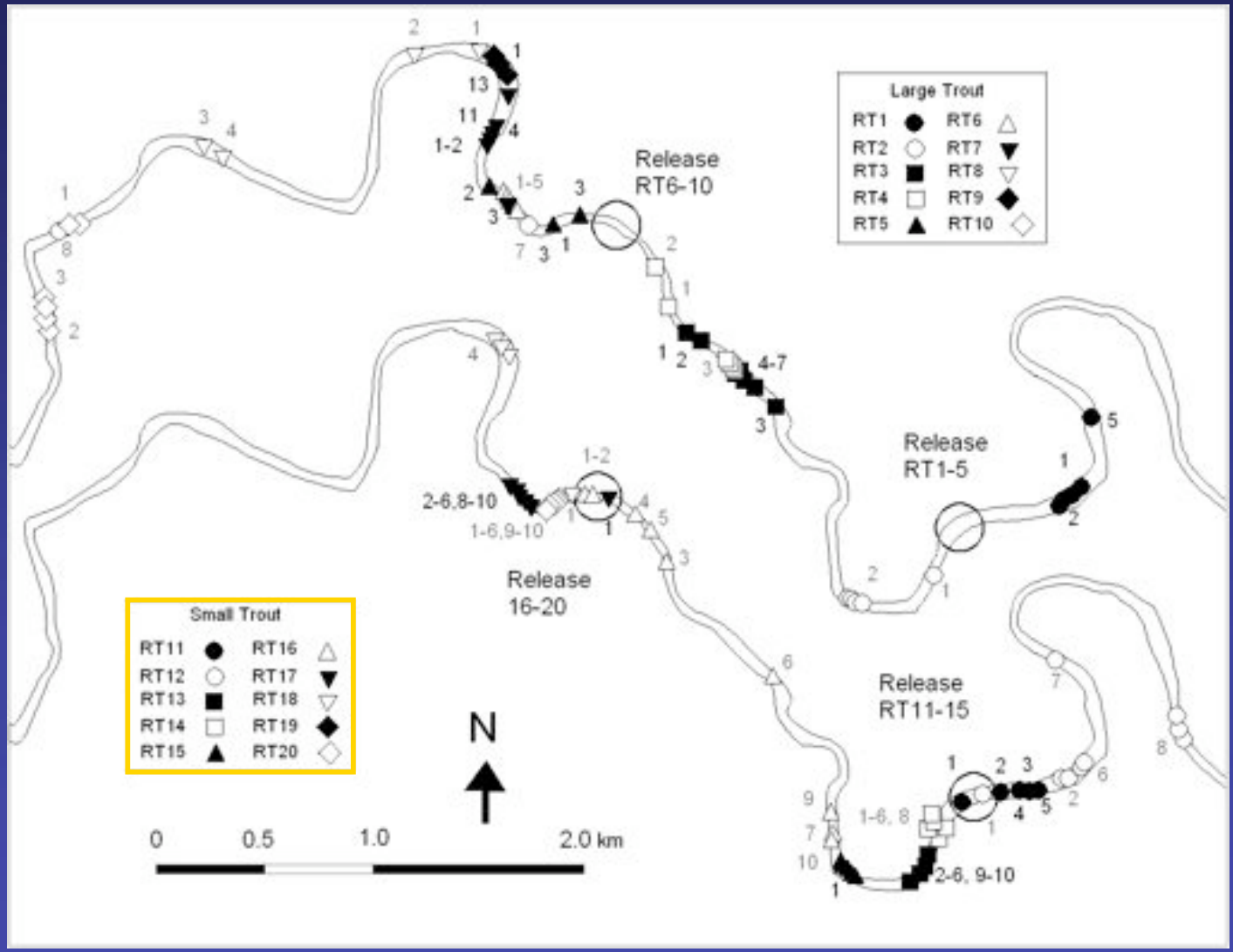
Radio Telemetry

- Radio tag inserted into the body cavity of 10 large and 10 small rainbow trout

- Tagged trout located weekly using a directional antenna

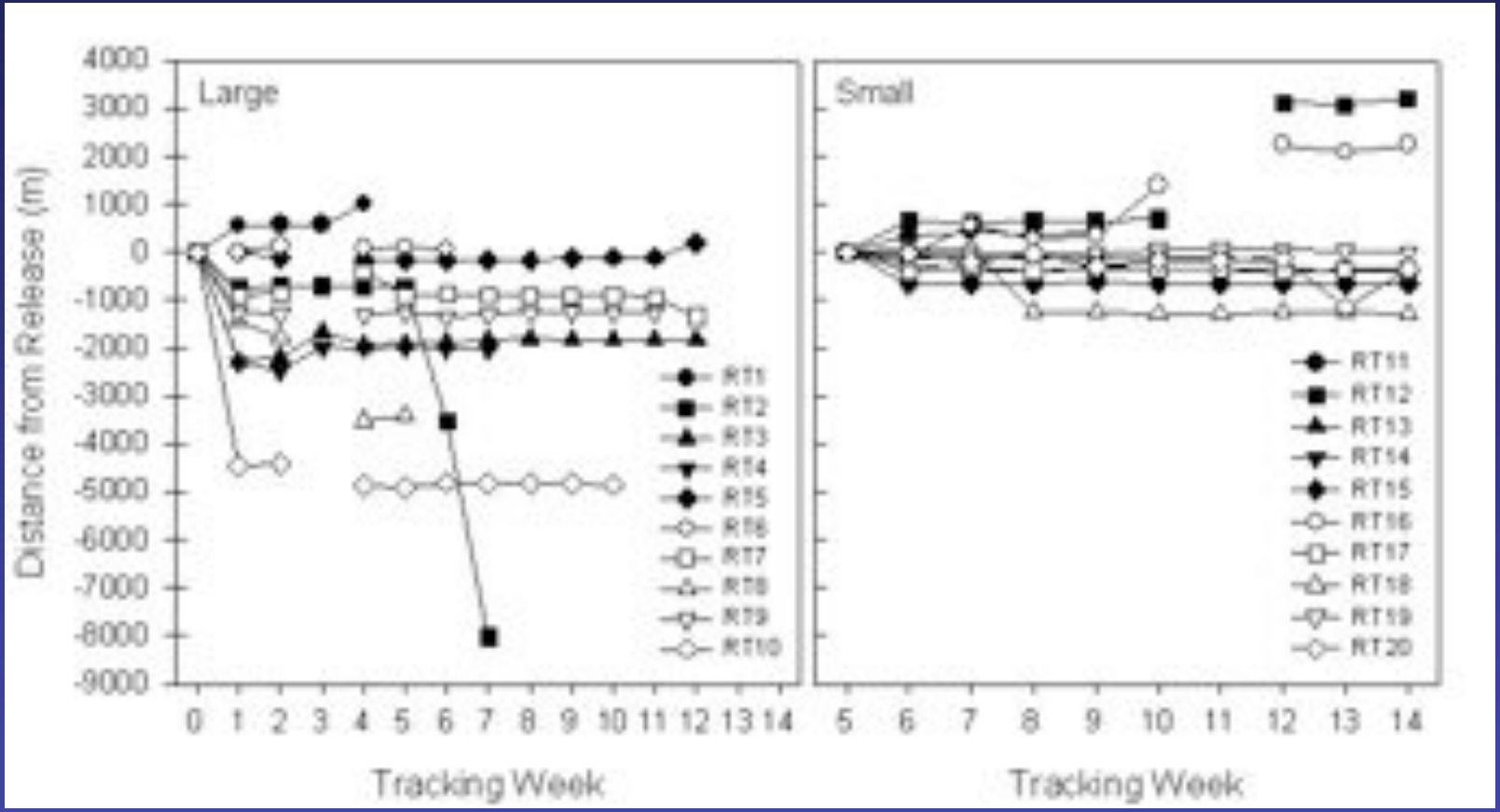
Longitudinal Displacement

ID	TL (cm)	Mass (g)
RT1	38.5	1242
RT2	35.0	970
RT3	34.0	909
RT4	36.0	1020
RT5	32.0	864
RT6	36.0	1050
RT7	38.0	1205
RT8	34.0	1115
RT9	36.0	1235
RT10	34.0	980
RT11	28.0	365
RT12	27.0	341
RT13	31.0	500
RT14	29.0	459
RT15	28.0	374
RT16	27.5	335
RT17	30.5	520
RT18	30.0	474
RT19	25.5	242
RT20	31.0	479



Hamilton et al. (In prep)

Distance of Movement



- Initial downstream or upstream movement during Week 1 for six fish, but little movement during Weeks 2-12, except for RT2
- Little movement downstream or upstream during Weeks 5-14

Hamilton et al. (In prep)

South Fork American River at Low Flow
(6 m^3/s; 200 cfs)

- Daily pulsed flow fluctuations create tidal zone along banks
- Cumulative impacts on habitat?
- Impacts on benthic macroinvertebrates?
  - (Munn & Brusven 1991, Bunn & Arthington 2002, Rehn et al. 2007)

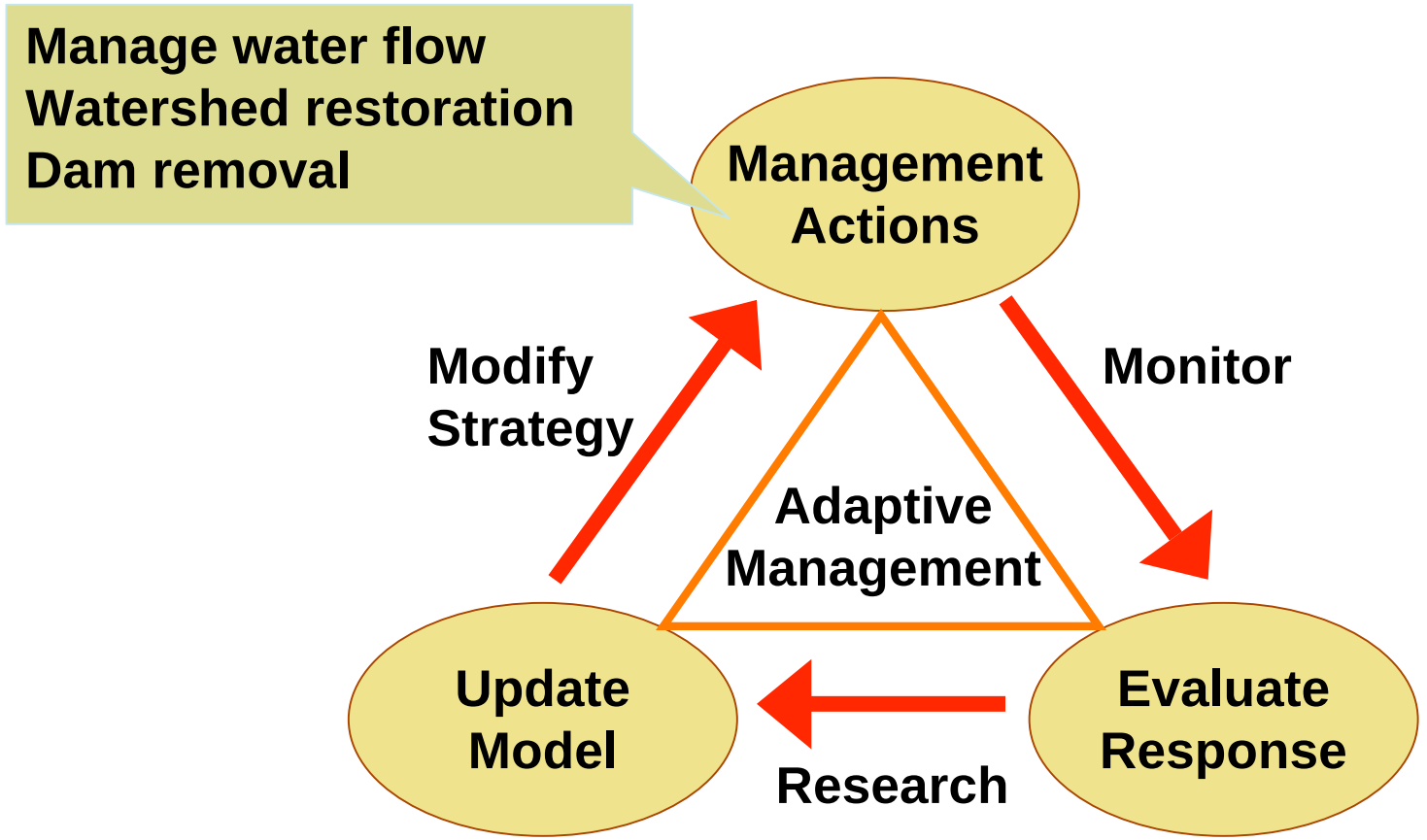
Current Situation in California

- State & federal ESA listings
- New water quality regulations
- Uncertainty & lack of understanding
  - Impacts of human activities on fish
  - What land & water management practices will best help fish?
  - *How much restoration would be enough?*

Dealing With Uncertainty

- We can act now, in spite of uncertainty
- Adaptive Management
- Restoration projects as experiments
  - "Learning by doing"
  - Test different management policies
  - Improve future restoration efforts
- Medical clinical trial

Adaptive Management Process



Habitat Restoration

- Restore logging roads
- Replant riparian vegetation
- Improve cattle grazing practices
- Improve irrigation practices
- Decrease water pollution

Dam Decommissioning

- **Matilija Dam (Ventura River watershed)**

- **Kilarc Project (Cow Creek)**
  - **Decommission and remove?**
  - **Keep and regulate flows to benefit fish?**

FERC Re-Licensing

- New flow regimes
- Compare neighboring rivers with different flow regimes
- American River watershed

North Fork

South Fork

Summary

- Fish distribution is related to local habitat conditions
- Longitudinal connectivity important for anadromous and resident fish
- Impacts of flow changes on fish may be direct and/or indirect
- Need to test restoration actions

Funding

- Cow Creek research supported by UC Davis
- Salinas River research supported by UC Cooperative Extension CORE grant program
- The pulsed flow portion of this research was supported by
  - Public Interest Energy Research Program (PIER) of the California Energy Commission
  - Division of Water Rights of the State Water Resources Control Board
  - Pulsed Flow Program of the Center for Aquatic Biology & Aquaculture (CABA) of the University of California, Davis